



CLINICAL ARTICLE

Increased width of the apical periodontal membrane space in endodontically treated teeth may represent favourable healing

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Abstract

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Aim To examine cases showing increased width of the periodontal space (IW) at a long-term follow-up examination and to determine whether this finding could be explained by endodontic or nonendodontic factors.

Methodology A series of intraoral radiographs was obtained from 131 patients 20–27 years after root canal treatment. The same individuals had been examined 10 years earlier, and radiographs taken immediately after treatment were also available. Fourteen roots (5.6%) demonstrated increased width of the apical periodontal space at the end of the study period. These were subjected to further analysis in an attempt to disclose possible explanatory factors.

Results Two of the 14 cases had reduced marginal bone levels interpreted as the origin of the IW. In three cases, overextended root filling material present 10 years earlier had disappeared and the persistent IW was interpreted as representing a remodelling process. In six cases the findings were explained as being caused by physical and anatomical factors that represented healing without complete re-formation of the apical periodontal structures, or both. Three cases were judged as unfavourable, on the basis of lacking progress in healing, unsatisfactory obturation of the apical portion of the root canal or dentine resorption close to the apical end of the root filling.

Conclusion Most of the 14 IW cases examined after 20–27 years could be explained by reduced marginal bone support, or by physical and anatomical factors or they might represent incomplete reformation of the typical apical morphology and were thereby recorded as favourable outcomes.

Keywords: oral radiology, periapical disease, prognosis.

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Introduction

Increased width of the apical periodontal membrane space is a common radiographic observation. The finding is often interpreted as an early sign of pathological alterations related to pulp necrosis and infection or as a late stage of healing after endodontic treatment of periapical disease. In other cases, with normal periapical findings at the start of root canal treatment, increased width of the periapical space is often considered the first radiographic sign of an unfavourable outcome. This finding may also have nonendodontic explanations, being the result of functional overload, for instance in cases with loss of supporting bone, or being related to physical or anatomical factors (Brynolf 1967, 1979).

The different origins of increased width of the periodontal space as observed radiographically indicate that in endodontic follow-up studies, these cases should be analysed to determine why they have increased width and preferably be classified among cases with an unfavourable or favourable outcome. For some cases this has been done by regarding those with a slight radiolucent zone around excess filling material as successes (Strindberg 1956, Grahnén & Hansson 1961, Kerekes & Tronstad 1979, Chugal *et al.* 2001, Peters & Wesselink 2002). In some studies they have been grouped as uncertain or doubtful (Strindberg 1956, Grahnén & Hansson 1961, Engström *et al.* 1964, Adenubi & Rule 1976, Kerekes & Tronstad 1979, Chugal *et al.* 2001). Furthermore, some investigators split the cases into favourable outcomes and failures (Harty *et al.* 1970), whilst others include the group among the successes (Morse *et al.* 1983, Petersson *et al.* 1986, Weiger *et al.* 1998, Molven *et al.* 2002) or roots with increased periapical width are left out (Kvist & Reit 1999, Hommez *et al.* 2002, Lupi-Pegurier *et al.* 2002). In three studies, however, cases recorded with increased width of the apical periodontal space were all re-evaluated jointly by the observers, related to explanatory factors, and placed if possible into a success/failure model. (Halse & Molven 1986, Molven & Halse 1988, Fristad *et al.* 2003).

The present study gives the result from an analysis of 14 endodontically treated roots with an increased width of the apical periodontal space at a 20–27 years follow-up of 265 root fillings. The aim was to determine whether a wider periodontal space than the typical appearance might represent a radiographically stable healing pattern and thereby be interpreted as a successful treatment result.

Materials and methods

A series of intraoral exposures was obtained from 131 patients 20–27 years after root canal treatment in the School of Dentistry, University of Bergen. The same individuals had been examined 10 years earlier. Details about the original material, and the follow-up group 10–17 and 20–27 years post-operatively have been reported in earlier articles (Molven 1976, Molven *et al.* 1985, Halse & Molven 2002).

Radiographic findings

All roots were initially classified into one of the following three groups: normal periapical findings, increased width of the periodontal space (IW) and pathological findings (Halse & Molven 1986, Molven *et al.* 2002). Overall, 193 of 265 roots were recorded with normal periapical conditions at both long-term follow-ups by two observers (A.H., O.M.) and not subjected to further evaluation. The remaining 72 filled roots were regarded as of interest and re-evaluated.

Apical periodontal space

The observers agreed that 22 of the 72 roots exhibited IW 10–17 years after treatment (Molven *et al.* 2002). The corresponding number at the 20–27-year follow-up was 14 roots or 5.3% of the total number of roots, recorded with a radiographic diagnosis. The 14 roots were subjected to further analyses by three observers, a radiologist (A.H.) and two endodontists (O.M., I.F.). The purpose was to relate the radiographic diagnosis IW to endodontic and other causative factors and further to classify each case either as favourable or unfavourable. During this analysis the following radiographs were available:

1 Radiographs taken immediately after root canal treatment.

2 The 10–17-year follow-up series.

3 The 20–27-year follow-up series.

The radiographs were exposed by a standardized paralleling technique, using film holder and a beam-aiming device. At the time of root filling one or more exposures were in addition made before removal of the rubber dam using a bisecting angle technique.

Results

At the 20–27-year follow-up 14 roots were recorded as IW. Three of these had been recorded as IW also at the 10–17-year follow-up, three as apical radiolucency and eight as normal (Fig. 1). Of the remaining 19 IW cases recorded at the 10–17-year follow-up, 18 were recorded as normal 10 years later and one as an apical radiolucency.

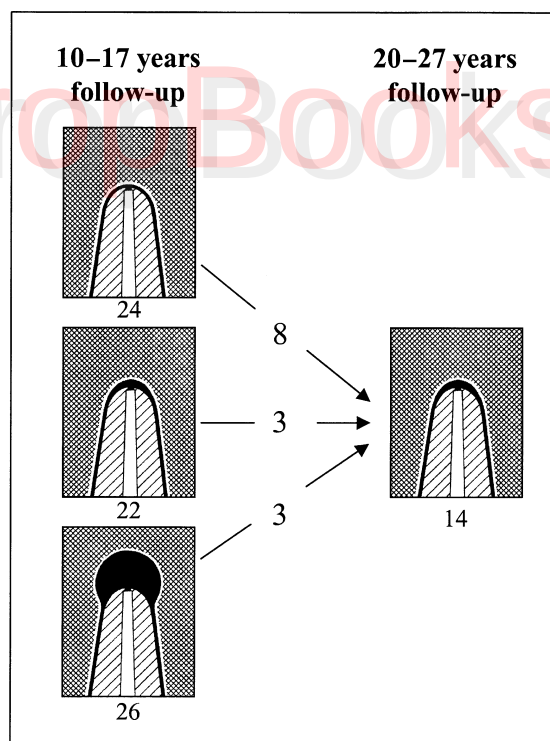


Figure 1 Periapical findings for 72 selected (see text) endodontically treated roots at a 10–17-year follow-up are given to the left. The origin of the 14 cases with increased width of the apical periodontal space (IW) at the 20–27-year follow-up is given by the number in the arrows.

Of the 14 cases evaluated one case showed a reduced marginal bone level interpreted as the origin of the IW. Loss of bony support was judged to be a contributory factor in three additional cases.

In three cases over-extended root filling material through the apical foramen present 10 years earlier had disappeared (Fig. 2). The persistent IW was interpreted as representing a remodelling process in the apical area.

Six cases showed some common features, but with no definitive single explanatory factor. The form of the root end in combination with low density of the surrounding bone or overprojected large bone marrow spaces was considered to have produced an image with a wider periodontal space than the typical one. From comparison with foregoing radiographs, findings were also interpreted as representing healing without complete reformation of the apical periodontal structures (Fig. 3). Two roots also exhibited a somewhat reduced marginal bone level.

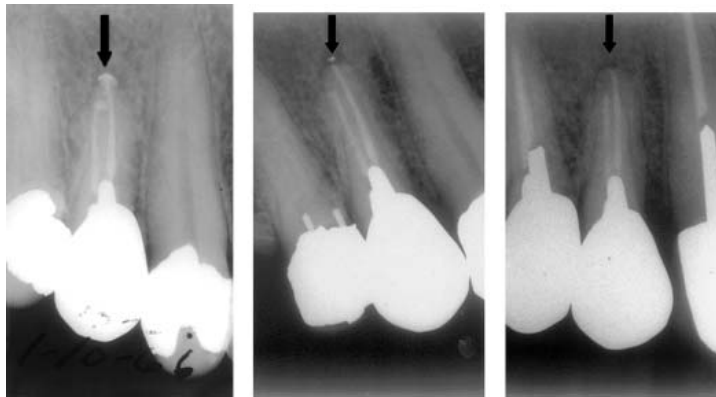


Figure 2 Maxillary first premolar, palatal root (arrow) immediately after root canal filling (left) shows apical periodontitis and marked over-extension of the root filling material through the apical foramen (overfilling). Follow-up after 14 years (middle): apical periodontitis and markedly reduced overfilling. Follow-up after 25 years (right): IW, overfilling disappeared. The finding was interpreted as remodelling after disappearance of surplus material, and the case was classified as having a favourable outcome.

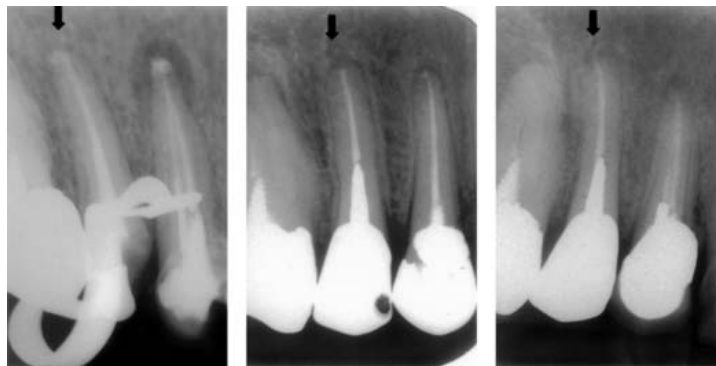


Figure 3 Maxillary second premolar (arrow) immediately after root canal filling (left) shows IW and overfilling. Follow-up after 11 years (middle): IW, overfilling disappeared. Follow-up after 21 years (right): IW. The finding was interpreted as healing without reformation of typical apical periodontal structures and classified as favourable. Note also first premolar (not included in the material) showing periapical radiolucency and marked overfilling shortly after treatment, reduced overfilling and apical periodontitis at first follow-up, while the last follow-up demonstrated absence of surplus material but a persistent apical radiolucency.

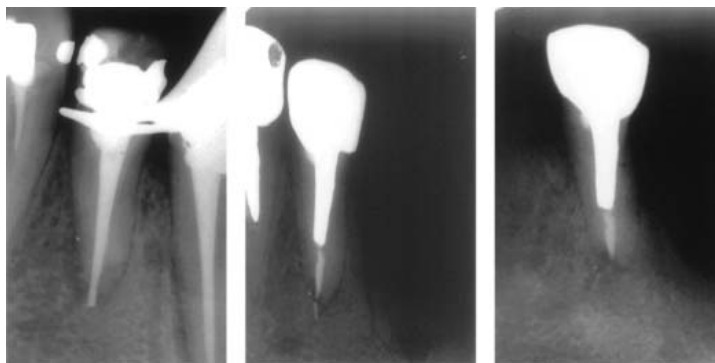


Figure 4 Mandibular first premolar immediately after root canal filling (left) shows apical periodontitis and marked overfilling. Follow-up after 12 years (middle): apical periodontitis, apical resorption and 'broken' overfilling. Follow-up after 22 years (right): IW, root resorption close to apical end of root canal filling. The finding was interpreted as incomplete disturbed healing, and the case was classified as unfavourable.

Four cases were judged as unfavourable. This decision was made on the basis of lacking progress in healing compared with earlier radiographs. Unsatisfactory obturation of the apical portion of the root canal or resorption of dentine close to the apical end of the filling was also observed as illustrated in Fig. 4.

Discussion

Increased width of the apical periodontal space (IW) was observed radiographically in 14 (5.3%) of the present 265 endodontically treated roots at a 20–27-year follow-up. When related to the periapical status immediately after root canal filling and findings made 10–17 years later, four cases (1.5%) were classified as unfavourable outcomes. For the remaining 11 roots (3.8%), the periapical situation could be linked to a favourable radiographic healing pattern related to surplus filling material or be explained by anatomical, physical and functional factors, and regarded as favourable outcomes.

The present findings should be related to the radiographic classification systems referred to in most endodontic studies; Strindberg's (1956) classification of treatment results and Brynolf's (1967, 1979) grouping of observations for nontreated and treated maxillary incisors. When widened periodontal contours were observed mainly around excess filling material, Strindberg (1956) assessed the results as successes, and as uncertain if 'the ambiguity of the radiographs could be due to marginal osteitis'. Later Brynolf (1967, 1979) established 'marginal osteitis' cases as a specific nonendodontic group among the IW roots, after correlating histological and radiological findings and excluding intermediate and deviating cases. So, she did not have to face the uncertainty often expressed in routine radiographic follow-up investigations, not only by Strindberg (1956) and others, especially regarding the IW group (see Introduction), but also in studies based on the PAI index (Ørstavik *et al.* 1986, Ørstavik 1996, Trope *et al.* 1999, Kirkevang 2001, Kirkevang *et al.* 2001). However, the findings reported in this study suggest that, at least in long-term follow-ups, careful analysis and judgement of IW cases may add to the information about the outcome of root canal treatment.

The radiographic diagnosis IW

IW is a minor, often diffusely expressed or barely visible aberration from the ideal, normal periapical radiographic image. This is primarily regarded as part of the

radiographic healing process or an early sign of an unfavourable development after root canal treatment (Kaffe & Gratt 1988, Whaites 1996, Ørstavik 1998). Thus, the finding belongs to the borderline group between the observed lesion and no lesion (Reit & Hollender 1983, Ørstavik *et al.* 1986, Kvist 2001, Halse *et al.* 2002) and difficulties are often encountered, not only during radiographic evaluation of the apical situation in endodontic follow-up studies and epidemiological investigations, but also in daily practice, for instance when the dentist has to decide whether a case should be retreated or not. The latter problem, endodontic retreatment decision-making, has been extensively discussed by Kvist (2001), whose primary advice for everyday practice is that 'a periapical lesion in a root-filled tooth that is not expected to heal should be retreated'. His five-graded Retreatment Preference Score widened contour – the cut-off point between a small lesion and no recorded lesion – is in accordance with the scoring system in earlier and recent papers in the present series (Halse & Molven 1986, Halse *et al.* 2002). However, Kvist's guiding rule could be supplemented with comments and advice regarding IW roots.

The validity of the diagnosis IW

Although the radiographic follow-up of endodontic treatment is widely considered essential for the individual patient as well as for scientific evaluation of different clinical variables, there is some uncertainty about its validity. The identification and evaluation of minor radiographic changes are important, but discrepancies exist between subtle radiographic diagnoses and the periapical situation as seen histologically (Ketterl 1963, Nicholls 1963, Rowe & Binnie 1974, Reit & Hollender 1983, Kirkevang 2001). Brynolf's (1967) histological findings on roots with a radiographically intact apical periodontium indicate strongly, however, that such roots represent a minor diagnostic problem, even when their histories are not known. The diagnostic uncertainty is thus mainly associated with the cases not showing the typical normal periapical morphology, often directly related to a change in the width and shape of the apical periodontal space with no obvious changes in bone structure.

It may be deduced that the gradually occurring healing with reformation of periapical structures reflects a regeneration of a functional periodontium as well, but to our knowledge no systematical histological study has been performed that verifies this assumption. The periodontal ligament is restored late in the periapical repair process, but little is known about the healing stages, both histologically and radiographically (Torabinejad & Walton 1994). In addition, in a clinical study, a supplementation with histological examination would meet with practical obstacles, and for asymptomatic cases it would be ethically unacceptable. Strindberg (1956) maintains however, based mainly on studies by Stein (1932) and Nygaard-Østby (1939), that there is not always *restitutio ad integrum* in root therapy; in other words, a complete re-establishment of normal structure will not always occur.

What then about IW as a final stage in the healing process, explained by fibrous tissue present periapically? There might be a parallel to the periapical healing after endodontic surgery, characterized by a variety of radiographic patterns, accepted as representing successful treatment results (Rud *et al.* 1972, Molven *et al.* 1987). Especially in relation to a resection of the apical end of the root, patterns with IW and no well-defined lamina dura may be observed, in some cases without re-establishment of functional periodontal fibres and with collagenous fibres running parallel to the root surface (Andreasen 1973). The surgical procedure differs from nonsurgical endodontic treatment, both through the intervention into the tissue adjacent to the tooth and also by exposing a dentinal surface. Even so, incomplete periapical reformation of tissues,

diagnosed as IW, may also be expected to occur occasionally after nonsurgical root canal treatment.

Validation of a diagnosis of IW can, to a high degree, be ascertained by a systematic follow-up procedure to study the stability of the radiographic appearance (Kaffe & Gratt 1988). Of the 22 cases recorded as IW 10–17 years after treatment only one case changed to an apical radiolucency 10 years later. This supports the view that most often the IW diagnosis represents a relatively stable condition with a positive prognosis.

The outcome – failures and successes

Three IW roots, or 1% of the total material, judged as unfavourable after 20–27 years, had also been classified with an unfavourable outcome 10 years earlier (Molven & Halse 1988). Thus, the influence from negative prognostic factors continued and the healing aberrations disclosed at the 10–17-year control persisted. This observation and earlier findings in the present material (Halse & Molven 1987, Molven & Halse 1988, Molven *et al.* 2002) support Strindberg's view that late failures are rare and that they 'only marginally affect overall evaluation of the periapical health'. The present long-term observations indicate that most IW roots, or 4% of the total material, should be considered favourable outcomes, thereby increasing the percentage of favourable cases. Thus, the analysis of the IW group seems important in a success/failure evaluation, probably also for investigators preferring the use of the PAI index (Ørstavik *et al.* 1986, 1996, Trope *et al.* 1999, Kirkevang *et al.* 2001). The PAI index implies that score 3 indicates periapical pathosis in an endodontically treated root (Ørstavik *et al.* 1986, Kirkevang 2001), and so IW roots should be given score 1 when explained functionally by loss of marginal bone, else score 2. The present study supports Kirkevang's (2001) view that the decision problems occur for score 2.

Clinical implications

The diagnosis IW may be made some time after endodontic treatment has been completed, both in teeth with and without apical lesions when the root canal treatment is performed. For the clinician the evaluation will be most difficult when an extensive restorative treatment is considered and an documentation about the endodontic treatment previous radiographs are lacking. The present findings indicate that generally in such cases the treatment outcome should be categorized as favourable. If resorption, defective seal or other possible negative prognostic factors are recorded, the case should be judged as unfavourable, and nonsurgical retreatment, endodontic surgery or extraction should be considered. In properly treated teeth with or without known pre-treatment diagnoses, the radiographic observation IW should be analysed and explained before it is recorded as a favourable outcome excluding retreatment.

Conclusion

The follow-up of 265 roots indicates that IW may be recorded a long time after treatment in 5–10% of the cases; 8.3% at 10–17 years and 5.3% at 20–27 years in the present material. Analysis of the IW roots showed that the majority could be explained by reduced marginal bone support, by physical and anatomical factors, or might represent an incomplete reformation of the typical apical morphology. These were recorded as favourable outcomes. IW roots indicating unfavourable outcomes were few and characterized by negative prognostic factors.

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